TROPOSPHERIC OZONE AT 45°S

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Abstract:
In August of 1986 a programme was initiated to measure atmospheric ozone profiles at mid-latitudes in the Southern Hemisphere by flying ECC ozonesondes on a regular basis from the DSIR Physical Sciences Atmospheric Laboratory at Lauder, New Zealand, 45°S. Flights since that time have been performed on a regular basis at the rate of two flights per week during the 5 month period August to December, the time of maximum variability at mid-latitudes , and once per week for the remainder of the year.

These data , consisting now of more than 400 profiles has been analysed and the free tropospheric portion of the profiles binned as 1km slabs. These data have then been combined to form a seasonal average values for each season of each year in 2 km slabs and the variation observed in these seasonal averages is the basis of this paper. A biennial component is apparent in these data and the lack of any increasing trend over this 5 year period is contrasted with that measured at similar latitudes in the Northern Hemisphere over the same period.

Introduction:
Tropospheric ozone can be produced by *in situ* chemistry (Crutzen, 1973; Chameides and Walker, 1973; Fishman and Crutzen, 1978) or by transport down from the stratosphere in a process that is considered to provide the "natural" or classical sink for stratospheric ozone.

It has recently been suggested however that the large reductions in stratospheric ozone observed in the lower stratosphere over the last decade, could result in a significant increase in tropospheric ozone and OH, (Schnell et al, 1991). Recent other work considering the influence of sulphate particles on climate change processes suggests that by increasing the backscattered short wave radiation, anthropogenic sulphur emissions may in fact have counteracted climate warming from the increased emissions of greenhouse gases, (Wigley, 1991). Since over 90% of the anthropogenic sulphur release to the atmosphere occurs in the Northern Hemisphere, and since the atmospheric lifetime of SO_2 and sulphate is less than one week in the troposphere, this process should be limited to the Northern Hemisphere. In fact, this latter effect is so significant that Charlson (1991) suggests that anthropogenic sulphur enhances the hemispherically reflected solar radiation to such an extent hat it masks the expected warming through the growth of CO_2 in the Northern Hemisphere. Such an effect could also have a direct bearing on the oxidising capacity of the troposphere as it may also work to reduce the formation of OH in the troposphere.

Staehelin and Schmid, (1991) have found a significant increase of in tropospheric ozone from their balloon sounding program at Payerne (Switzerland), . They report an increase that on average amounts to more than 1% per year over the last 20 years. It is against this background that it is interesting to consider what is happening to tropospheric ozone at similar latitudes in the Southern Hemisphere.

Database and Analysis:
In August of 1986, an ozonesonde sounding program was instituted at Lauder, New Zealand, 45°S. Lauder itself is located in the southern centre of the South Island of New Zealand and is 40km away from the nearest population "centre", Alexandra (population 4000). The site is 150km from the ocean and has been chosen as the Mid-latitude Southern Hemisphere Charter site for the international 5 station Network for the Detection of Stratospheric Change (NDSC).

Flights using regular type 4A ECC ozonesondes in conjunction with Phillips radiosondes operating at 1680MHz were flown on the regular basis of one flight per week augmented by an extra flight per week in the spring early summer period (August through December). The resulting chart records were then interpreted manually. At the end of 1989, a change was made to a fully digital system incorporating type 5A ECC ozonesondes and Vaisala RS80 radiosondes. This system was interfaced using a microprocessor controlled multiplexer board from TMax back to the Vaisala transmitter so that the hex-ASCII serial data stream can be transmitted to the ground station at 403MHz and is directly accessible by a PC. Ozone, pressure, ambient temperature and humidity were analysed from each

flight record. The measured ozone amounts were corrected for variations in the pump temperature, which was monitored directly and for pump efficiency, where an empirical correction was applied. The ozone measurement accuracy has been assessed in many studies and has found to be ±10% in the troposphere, ±5% in the stratosphere to 10hPa and ±5 to ±20% between 10 and 3hPa, Hilsenrath et al., (1986).

The Lauder data series, consisting now of more than 400 profiles has been analysed and a subset of flights was then selected where there was a single well marked tropopause. This method was used to minimise the influence of stratospheric "contamination" of the tropospheric data by direct stratospheric / tropospheric exchange. The free tropospheric portion of the profiles was then binned in 1km slabs. These data have then been combined to form a seasonal average values for each season of each year in 2 km slabs The number of flights used in each compilation for each season is given in Table 1.

Table 1

Number of Flights in each Season					
Month	**FMA**	**MJJ**	**ASO**	**NDJ**	**Total**
1986			22	14	36
1987	10	13	20	13	56
1988	12	13	19	12	56
1989	9	11	23	16	59
1990	11	10	21	16	58
1991	10	12	24	20	66

The each data point in the series of figures that follow represents an average of 6 individual measurements for each 2km slab per flight in the analog data set and an average of 36 measurements for the digital data set. The 1 sigma error bars are shown in each figure.

Results and Discussion:

In the series of figures that follow, the 2km bin data is presented as a function of season for each year. The 'seasons' have been chosen through consideration of the phase of the annual cycle in total ozone at mid-latitudes. The grouping of months February , March and April (FMA) coincide with the total ozone minimum in the Southern Hemisphere, while the grouping August, September and October (ASO) coincide with ozone maximum.

Figures 1(a) to 1(d) show the temporal variation in tropospheric ozone over Lauder in the November, December and January, (NDJ), period for the available time series. The data centered at each 5, 6, 7 and 8kms all show the same form. There is evidence of a 2 year periodicity and a slight downward trend. The summer period typically has a higher

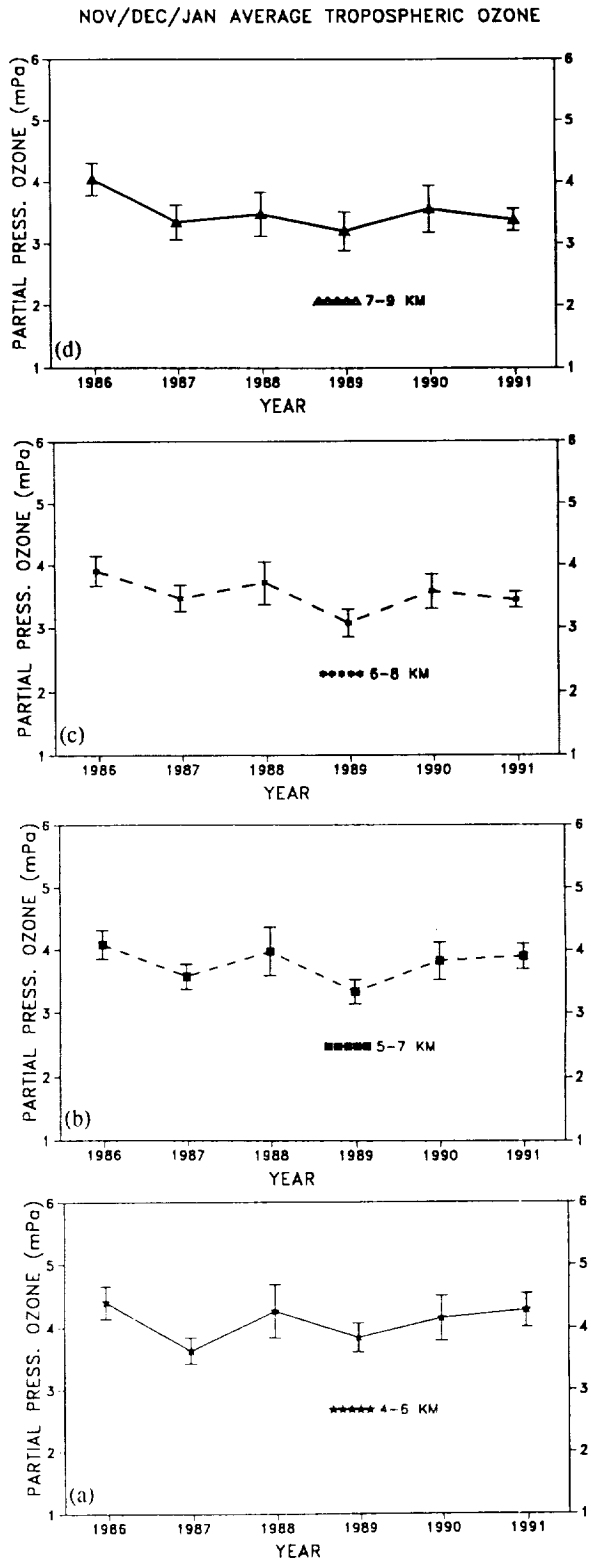

Figure 1: The temporal variation in ozone in a 2km slab over Lauder, centered at (a) 5km, (b) 6km, (c) 7km and (d) 8 km respectively is shown for the November, December, January, (NDJ) period from 1986.

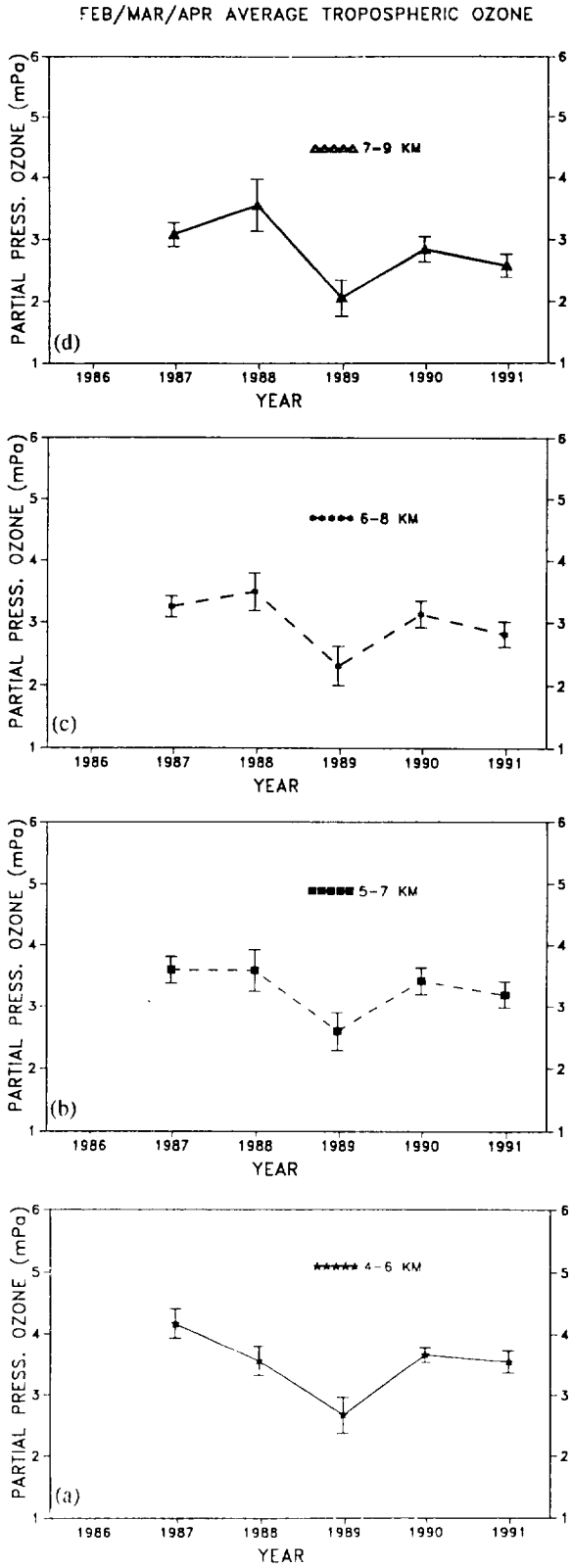

Figure 2: Same as for Figure 1 but for the February, March, April (FMA) period from 1987.

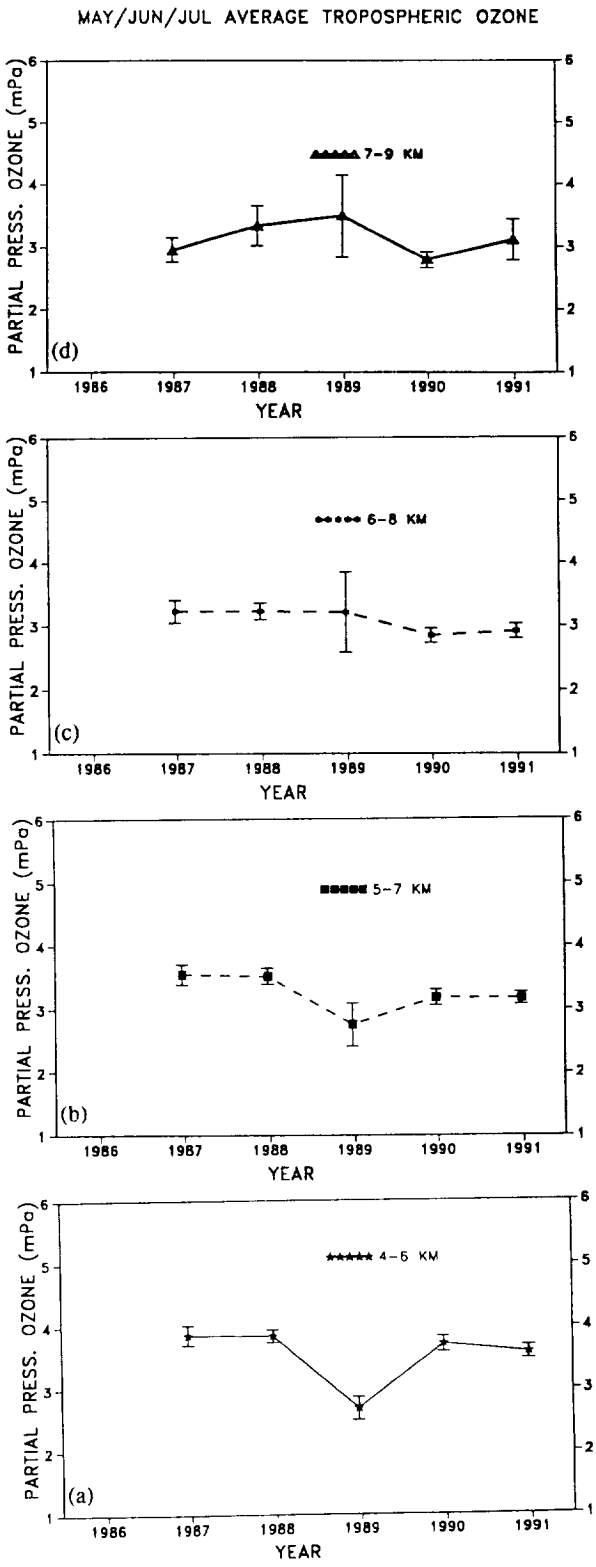

Figure 3: Same as for Figure 1 but for the May, June, July, (MJJ) period from 1987.

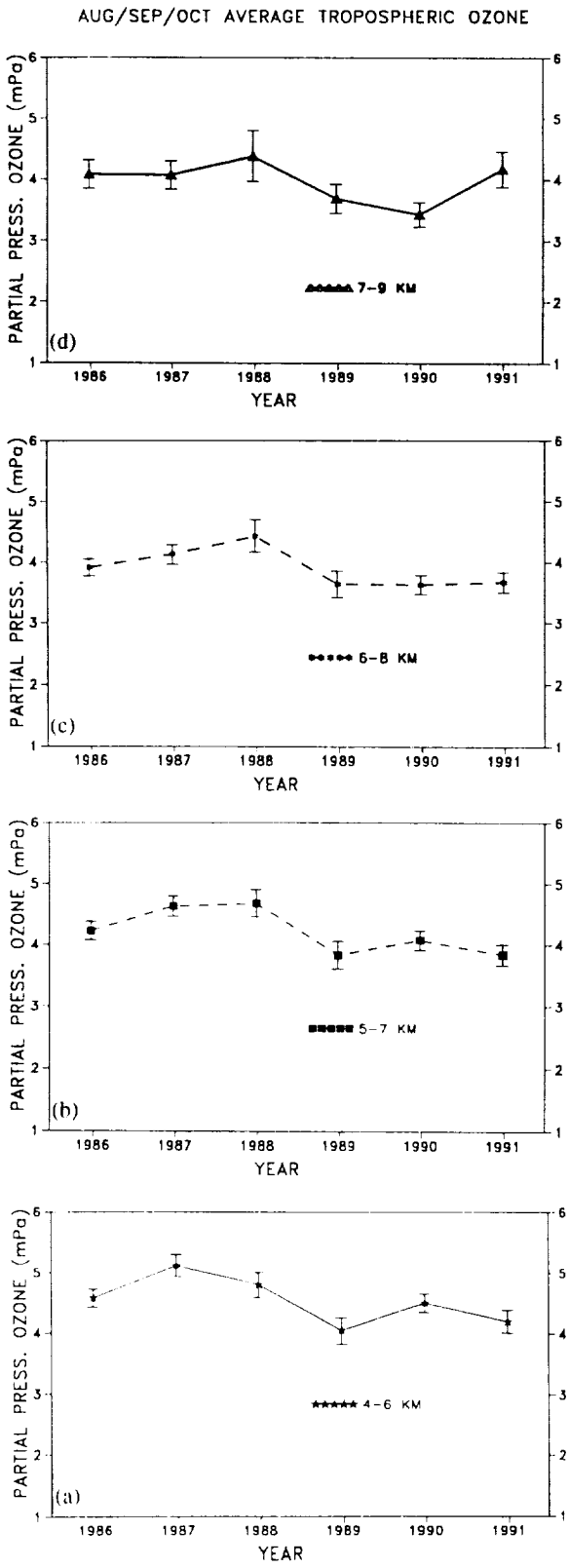

Figure 4: Same as for Figure 1 but for the August, September, October, (ASO) period from 1986.

tropopause and hence there is no evidence of stratospheric exchange processes interfering with even the 7-9km bin at this time of the year. The FMA data, figures 2(a) to 2(d), also show a similar 2 yearly feature, especially in the upper troposphere but the marked feature in these figures are the much lower values recorded in 1989. There is again a suggestion that the tropospheric levels have decreased over the period. The MJJ data, figures 3(a) to 3(d), again show that the tropospheric values in 1989 were much lower than in any other year in the period. The lower tropopause in winter and the occasional folding observed at this time of the year has possibly influenced the data in the 7-9km bin, figure 8, and hence this graph shows a shape that differs from the rest of the series. The period ASO in the spring, figures 4(a) to 4(d), is the time of ozone maximum in the column and also when the highest tropospheric concentrations are observed. It is also the time of greatest variability as evidenced by the larger standard deviations despite the larger data sample. A longer term oscillation is also evident in these data as well as a slight downward trend.

This 5 year data series from mid-latitudes in the Southern Hemisphere demonstrates that over this period, tropospheric ozone levels have not risen at a rate seen in the Northern Hemisphere and in fact there is a suggestion that tropospheric ozone levels may have reduced. A longer time series will in the future establish whether this change is significant and has been sustained.

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